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ABSTRACT

A series of experiments were conducted to study variables affecting the alignment of blind pedestrians at street intersections. In the first two studies blindfolded sighted students, serving as adventitiously blind people undergoing mobility training, learned one of three strategies: no concrete strategy, tracking, and tracking and compensation. In the study, blind and blindfolded students were asked to align themselves to parallel oncoming and cross traffic. Results of the studies indicate that Ss preferred to track a car through the intersection and compensate rather than listen for the frequency and intensity shift of the passing car. Results supported reports of blind travelers that parallel traffic, especially parallel ongoing traffic, is more useful than cross traffic or turning traffic for mobility. Finally, blind and trained subjects needed only one parallel ongoing car for good alignment, indicating that alignment to traffic sounds can be both quick and accurate. Implications for mobility training and the study of ecological acoustics are discussed. (Author/CL)

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The Use of Traffic Sounds by Blind Pedestrians

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The following paper was presented at the meeting of the Midwestern Psychological Association, Chicago, May 1984.

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Abstract

Blind pedestrians must use sounds for proper alignment at street intersections. Blind or blindfolded subjects were tested to study different variables that affect alignment accuracy. With extensive practice and an appropriate strategy, subjects learned to use traffic sounds for accurate and rapid alignment. Implications for mobility training and the study of ecological acoustics are discussed.

The Use of Traffic Sounds by Blind Pedestrians

Blind pedestrians must use sounds for spatial orientation. One particularly important source of auditory information is traffic sounds. Blind pedestrians use traffic sounds to learn about the spatial layout of an area, maintain orientation to the environment, and guide locomotion. While walking, for example, they try to keep parallel to the flow of traffic to avoid accidentally veering into the street or walking into a driveway or parking lot. At intersections, traffic sounds indicate the size and shape of the intersection and how traffic is regulated. More importantly, blind pedestrians use traffic sounds to make sure they are properly aligned for a straight and safe crossing.

As a blind pedestrian approaches an intersection, they may veer and face into the intersection, making what Mobility Instructors call an "outside" crossing. Or they may walk into the cross street making an "inside" crossing. Mobility instructors train blind people to listen to traffic sounds and avoid making inside or outside crossings. But it is not known how well people can learn to use traffic sounds for spatial orientation.

Psychophysical studies of sound localization indicate that hearing is not a very accurate spatial sense. However, the results of these studies cannot be generalized to the mobility situation. The blind pedestrians' head is free to move and cars are moving and variable sound sources. Therefore, blind pedestrians can track a car's movement and make use of the Doppler shift of frequency or the change in intensity of sound as cars pass by them. On the other hand, there are masking sounds

from idling cars and busses and echoes from the street and buildings.

Blind pedestrians may also employ cognitive strategies to compensate for the poor spatial resolution of hearing. They must know, for example, how intersections are typically laid out to make use of traffic sounds. They may also know how reliable and useful different kinds of traffic are and employ a strategy to align themselves with traffic sounds. Indeed, Mobility Instructors have developed several different strategies for using traffic sounds for alignment, though the effectiveness of these strategies has not been objectively evaluated.

The experiments I will describe addressed the following questions: 1) What is the speed and accuracy with which blind travelers can align themselves at intersections, 2) What is the most effective alignment strategy, 3) What is the course of learning for this skill, and 4) How useful are different kinds of traffic.

General Method

For all experiments, alignment accuracy was measured by a spotting compass mounted at the midline of the head. A sighting portal at the rear of the compass permitted compass readings to within 1° accuracy. For a trial, subjects were led around by sighted guide technique to disorient them and were then led to a particular spot at an intersection. Next they were rotated to some point ± 80 degrees from perfect alignment. They then tried to align themselves with traffic by rotating their body to the correct direction. The magnitude and direction of alignment error was determined by taking the compass reading of the direction

their head was pointing and subtracting the reading for proper alignment. Time required for alignment was measured by a stopwatch. Subjects were given feedback about their performance by rotating them to proper alignment.

Experiments

In the first experiment, three different alignment strategies were tested over a period of three days with parallel ongoing traffic in the near lane (street on subjects' left) and with parallel oncoming traffic in the near lane (street on subjects' right). The three strategies tested were compiled from mobility instructors, experienced blind travelers, and mobility handbooks. Blindfolded sighted students served as adventitiously blind people undergoing mobility training. Each learned one of the following strategies.

1) No Strategy--Subjects are instructed to "project across" the intersection and make sure traffic is in proper registration. This method offers no concrete strategy for alignment.

2) Tracking--Subjects are to track a car going in the same direction they are and face the last point they can hear the car. That point is proper alignment.

3) Tracking and Compensation--Subjects are to track a car through the intersection and compensate in for where the corner should be. The longer they can track a car, the less compensation required.

Note that the two tracking strategies rely exclusively on parallel traffic, especially parallel ongoing traffic, and do not make use of the frequency and intensity shifts of passing cars. The No Strategy

group, however, is free to use parallel or cross traffic and may also make use of frequency and intensity changes.

Subjects were tested at one of two intersections over a period of three days. On each day they were given eight trials with parallel ongoing traffic in the near lane and eight trials with parallel oncoming traffic in the near lane. In addition to the three groups of blindfolded sighted subjects, a group of experienced blind travelers were tested to assess the effects of long term practice.

Figure 1 shows the performance of the three strategy groups over days. Mean absolute error from perfect alignment, irrespective of direction, is plotted on the ordinate. The performance of the blind control group and a sighted control group is plotted on the far right. All groups improved over days. The three strategy groups were comparable, but this result is misleading. A debriefing at the end of each day showed that most subjects abandoned their given strategy and developed their own. Twenty-one of the subjects used a tracking and compensation strategy, while six subjects used other strategies such as listening for the loudest point as cars passed by or using turning cars. When the data are analyzed according to actual strategy used, the tracking and compensation strategy led to significantly better performance than other strategies (see Figure 2). Not surprisingly, then, most blind and blindfolded subjects preferred parallel ongoing traffic. Even so, there was no difference in performance between the two types of parallel traffic (see Figure 3). Subjects typically picked up oncoming traffic ahead of them instead of tracking cars as they went behind them. Cross traffic and turning cars were considered either not very useful or

distracting. The performance at the two intersections was comparable (see Figure 4). A subset of subjects were run for a fourth day at the alternative intersection to test if alignment skill would transfer to a new intersection. The results, shown in Figure 4, indicate a significant amount of transfer of training, even though the two intersections differed markedly in size and traffic flow. This result suggests that alignment skill is a general one and not specific to a particular intersection.

With three days of practice, blindfolded subjects' performance became comparable to blind subjects' performance at a new intersection. This suggests that performance could be improved with more practice. In Experiment 2, a group of subjects were tested for seven days. They were not given a concrete strategy to use but all developed a tracking and compensation strategy. The results show that with extensive practice, alignment can be fairly accurate, though not as accurate as sight (see Figure 5). All subjects preferred the parallel ongoing traffic, but once again there was no difference between the two types of parallel traffic. There were wide individual differences in performance as can be seen in Figure 6, which plots the performance of the best versus the worst subject. But for all subjects, the standard deviation of their performance decreased over days (see Figure 7). That is, their judgments became more consistent over days.

In the first two experiments, the speed of alignment was measured as the total time required for a subject to make a judgment. Subjects took less time over trials, but time was comparable over days. This is a gross measure of alignment speed because the type, amount and speed

of traffic is free to vary. A better measure of speed of alignment is the number of cars required for alignment. A third experiment was carried out to measure speed of alignment in this way.

Blind subjects and the blindfolded subjects from Experiment Two were placed in the middle of a block in a quiet residential neighborhood. A research assistant drove a car past at a speed of 25 mph. For a trial, subjects had three passes of the car to align themselves. Alignment accuracy was measured after each pass, but feedback was given only after the third pass of the car. A trial was discarded when any other vehicle drove down the street, or when we were stopped and questioned by the police. Subjects had four trials as if they were aligning themselves to parallel oncoming traffic, and four trials as if aligning to cross traffic. A control group of untrained blindfolded subjects was run with parallel ongoing traffic to guard against ceiling effects. The results, shown in Figure 8, show that parallel ongoing traffic is the most useful for alignment (in the left panel), followed by parallel oncoming traffic (the middle panel) and finally cross traffic (the right panel). For parallel traffic, only one car was needed for accurate alignment. Most subjects reported high confidence in their alignment after one or two car passes. Alignment to cross traffic did not improve with passes of the car and both blind and blindfolded subjects reported low confidence in their judgments. Even in a situation of uniform traffic flow, subjects were able to align themselves more accurately when traffic was traveling parallel to them than when it passed in front of them.

Conclusions

The research I have presented indicates that hearing can provide useful spatial information. Developing the ability to use traffic sounds takes extensive training and the use of an appropriate cognitive strategy. Subjects preferred to track a car through the intersection and compensate rather than listen for the frequency and intensity shift of the passing car. The results also support the reports of blind travelers that parallel traffic, especially parallel ongoing traffic is more useful than cross traffic or turning traffic for mobility. Finally, blind and trained subjects needed only one parallel ongoing car for good alignment, indicating that alignment to traffic sounds can be both quick and accurate.

Acknowledgements

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Figure 1. Degree deviation from proper alignment, irrespective of direction, for three alignment strategies over three days.

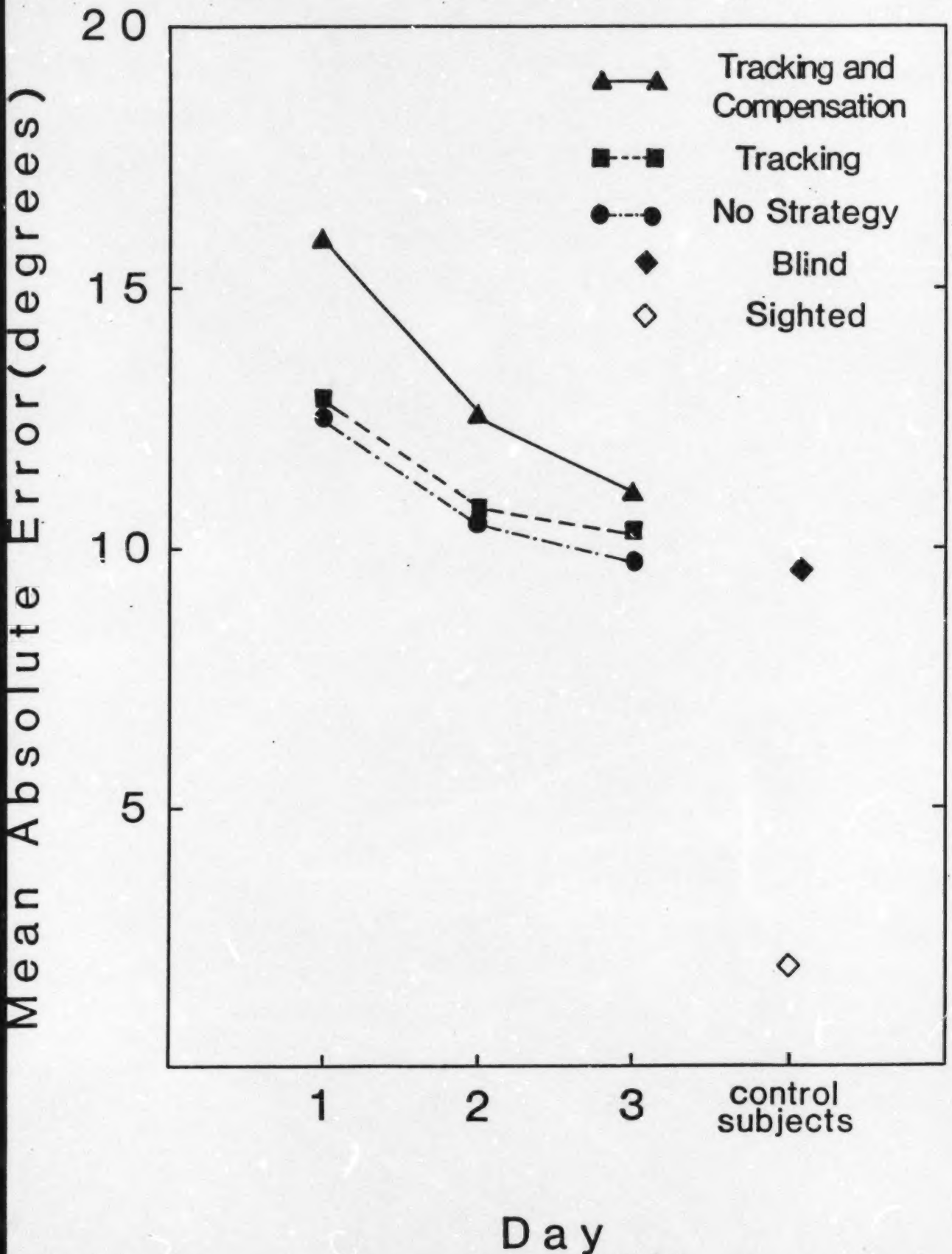


Figure 2. Degree deviation from proper alignment, irrespective of direction, for Tracking and Compensation vs. Other Strategies.

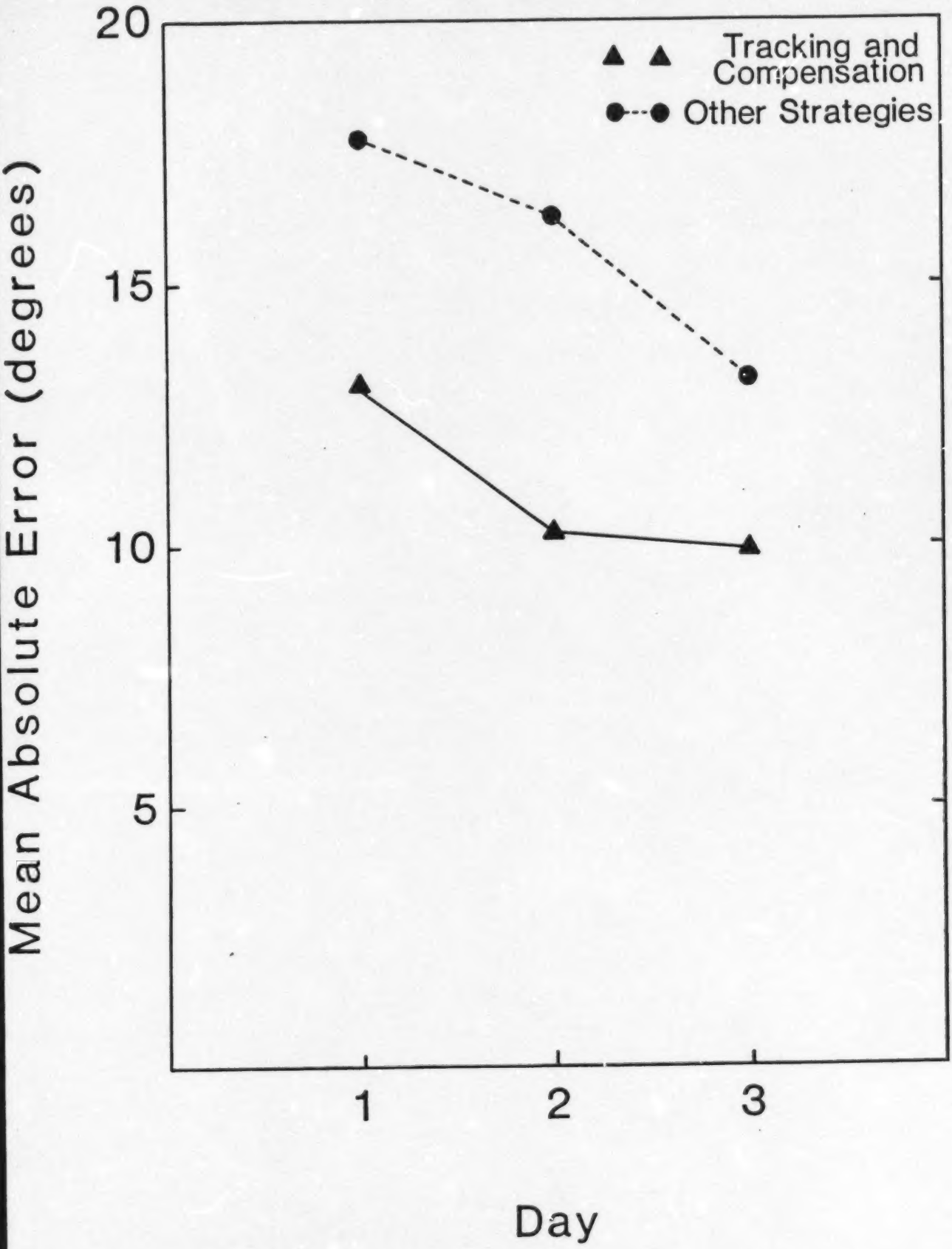


Figure 3. Comparison of alignment performance with Parallel Ongoing vs. Parallel Oncoming Traffic in the near lane.

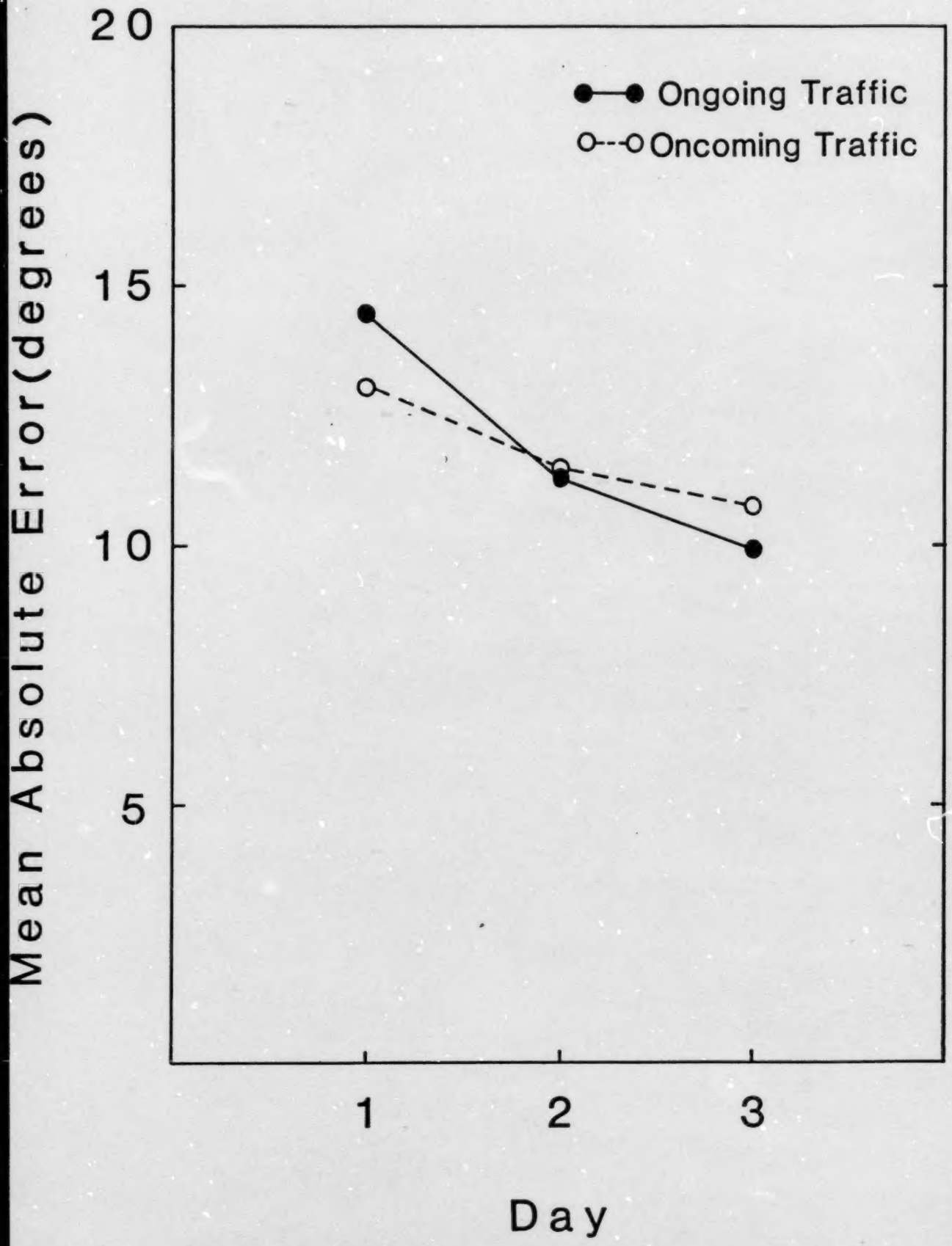


Figure 4. Comparison of alignment performance at two intersections and the transfer of training from one to the other.

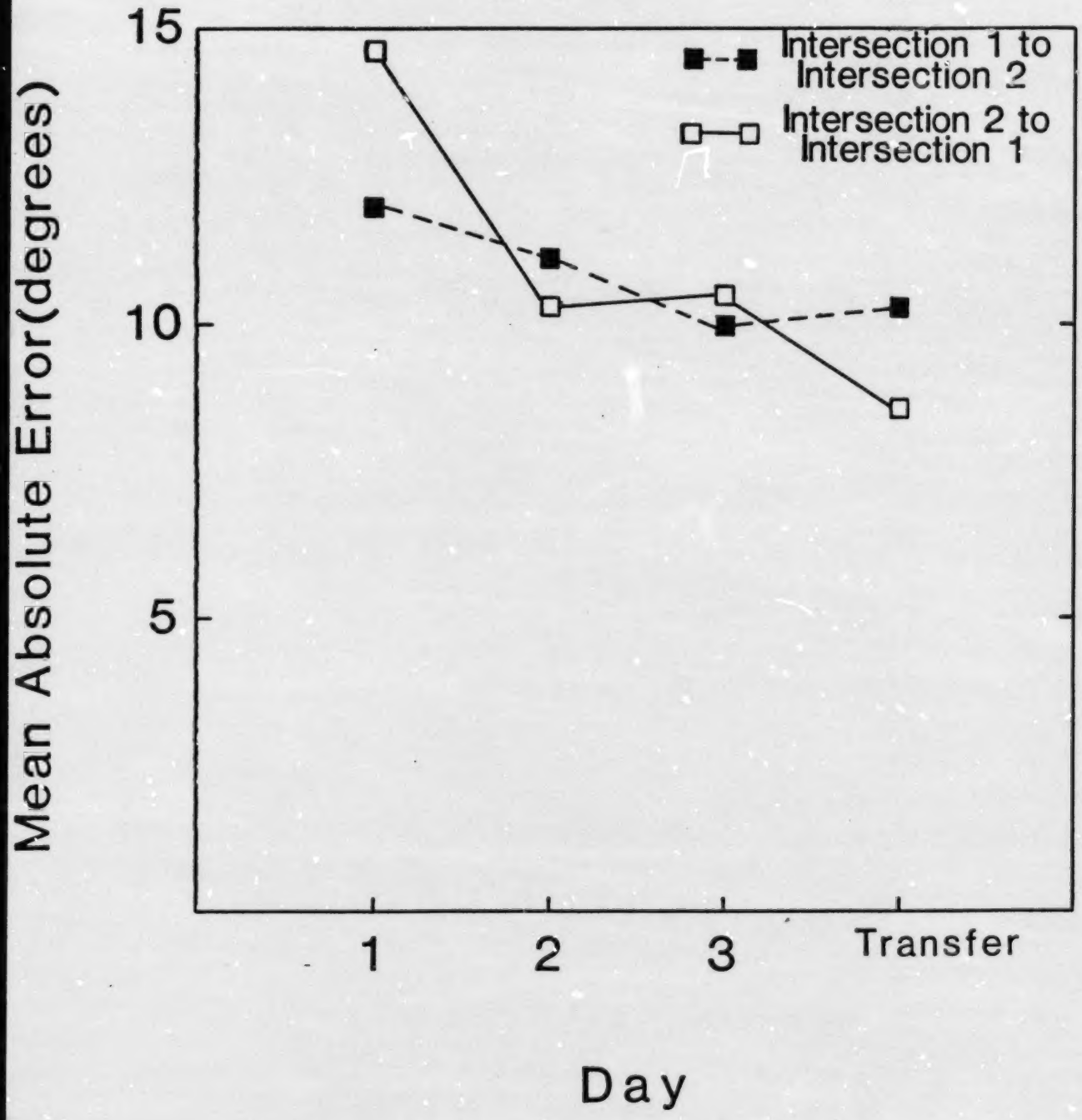


Figure 5. Degree deviation from proper alignment, irrespective of direction, over seven days.

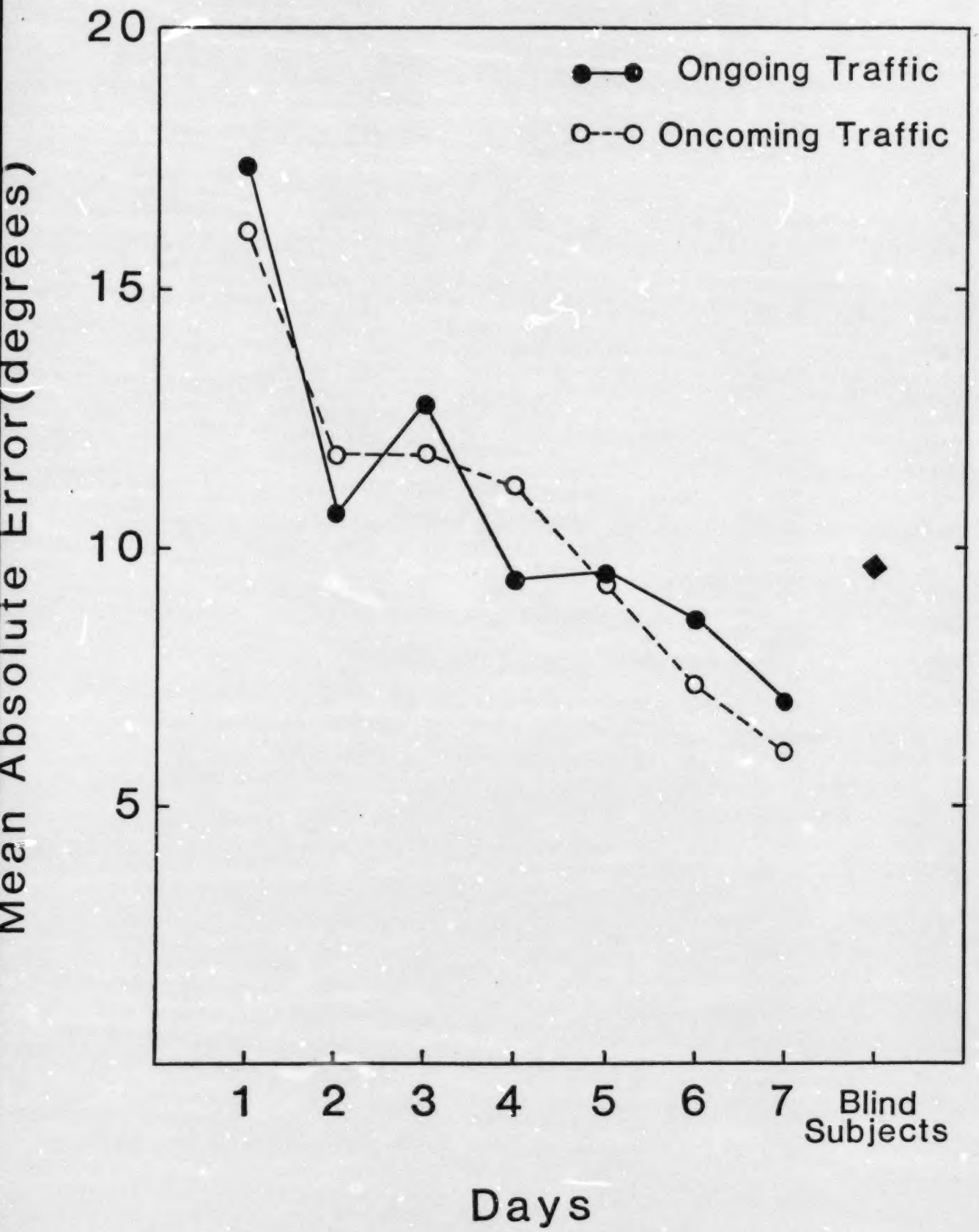


Figure 6. Comparison of alignment performance of the most proficient vs. least proficient subject.

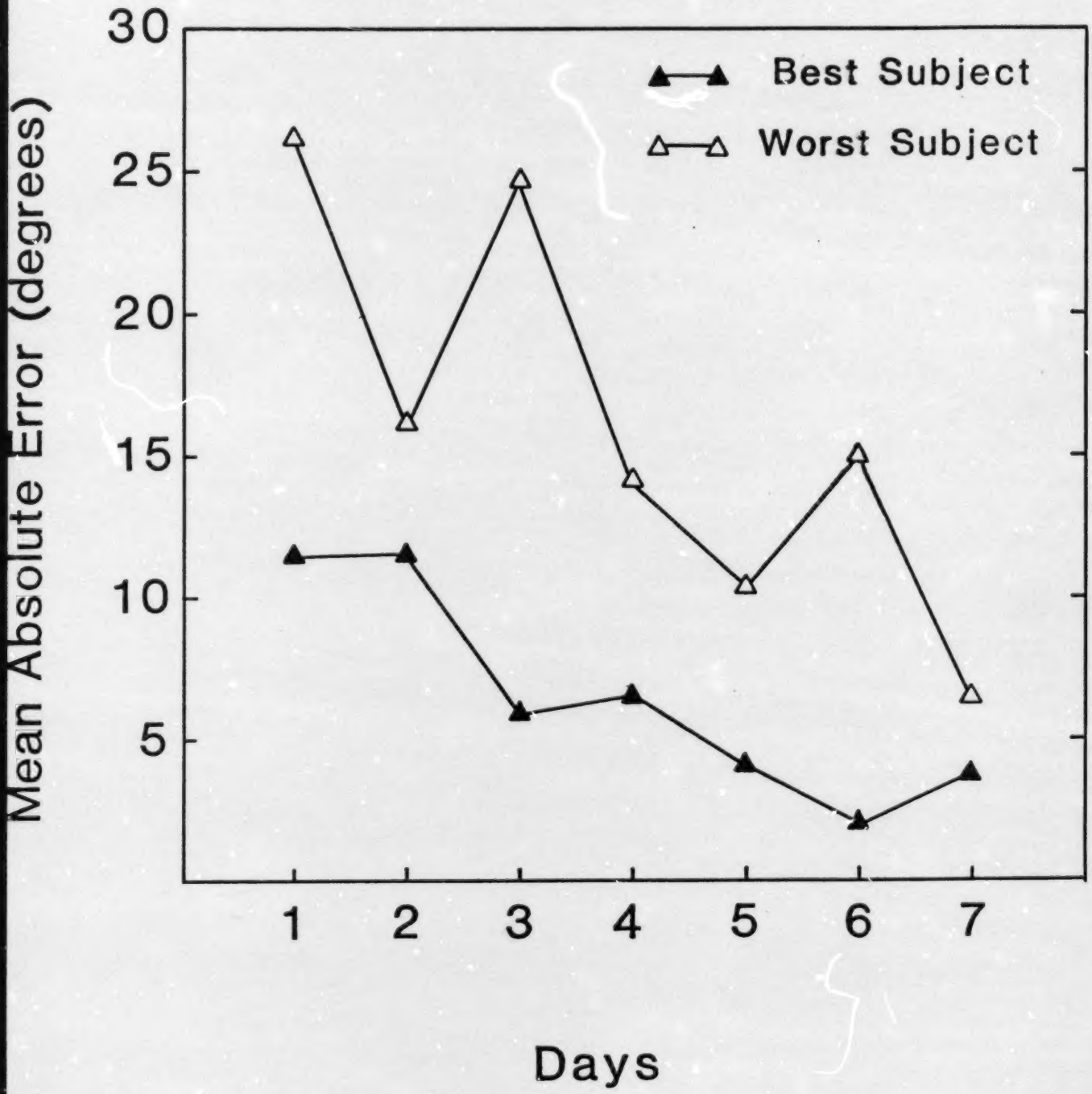
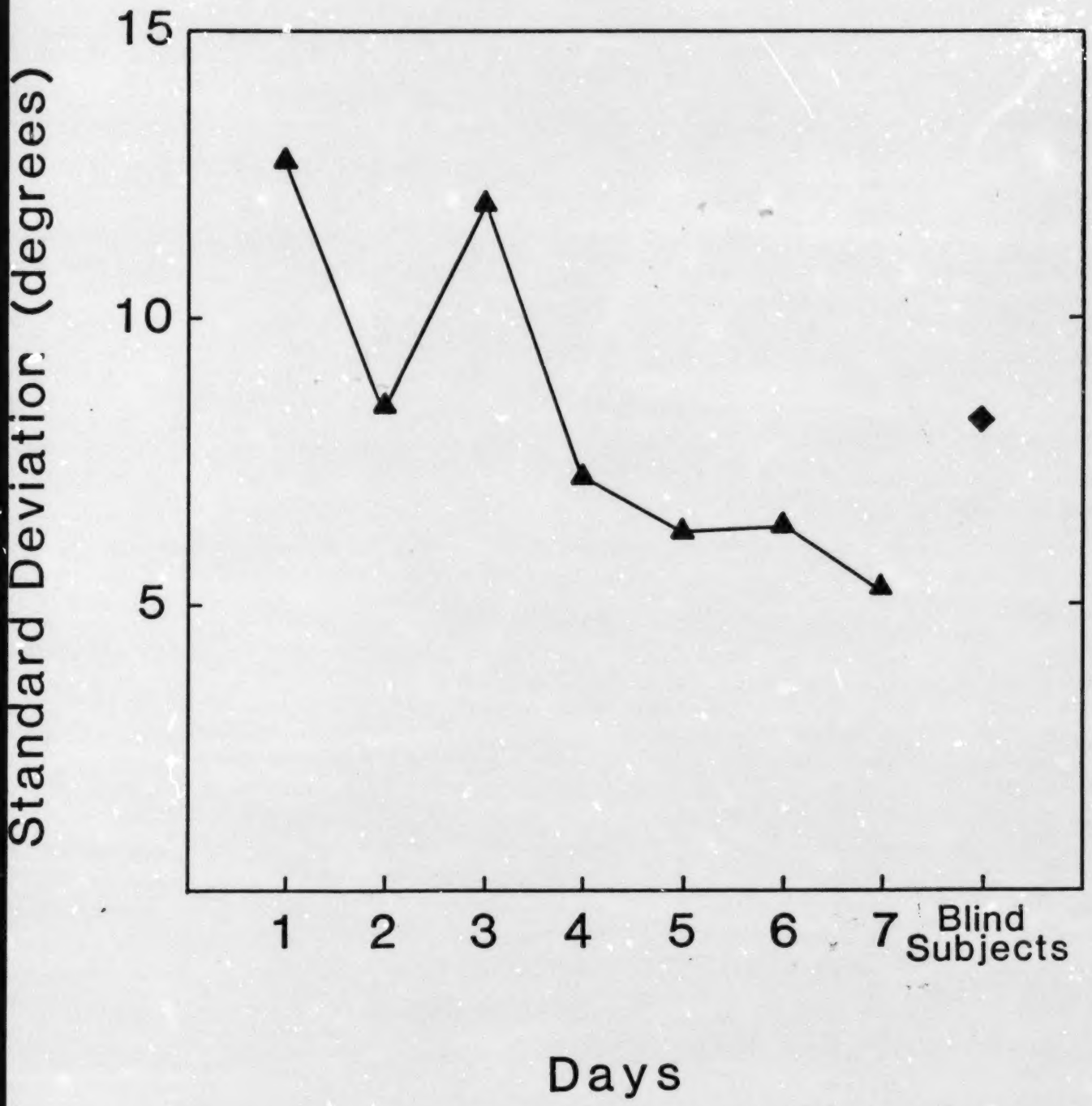


Figure 7. Comparison of standard deviations of absolute error over seven days.



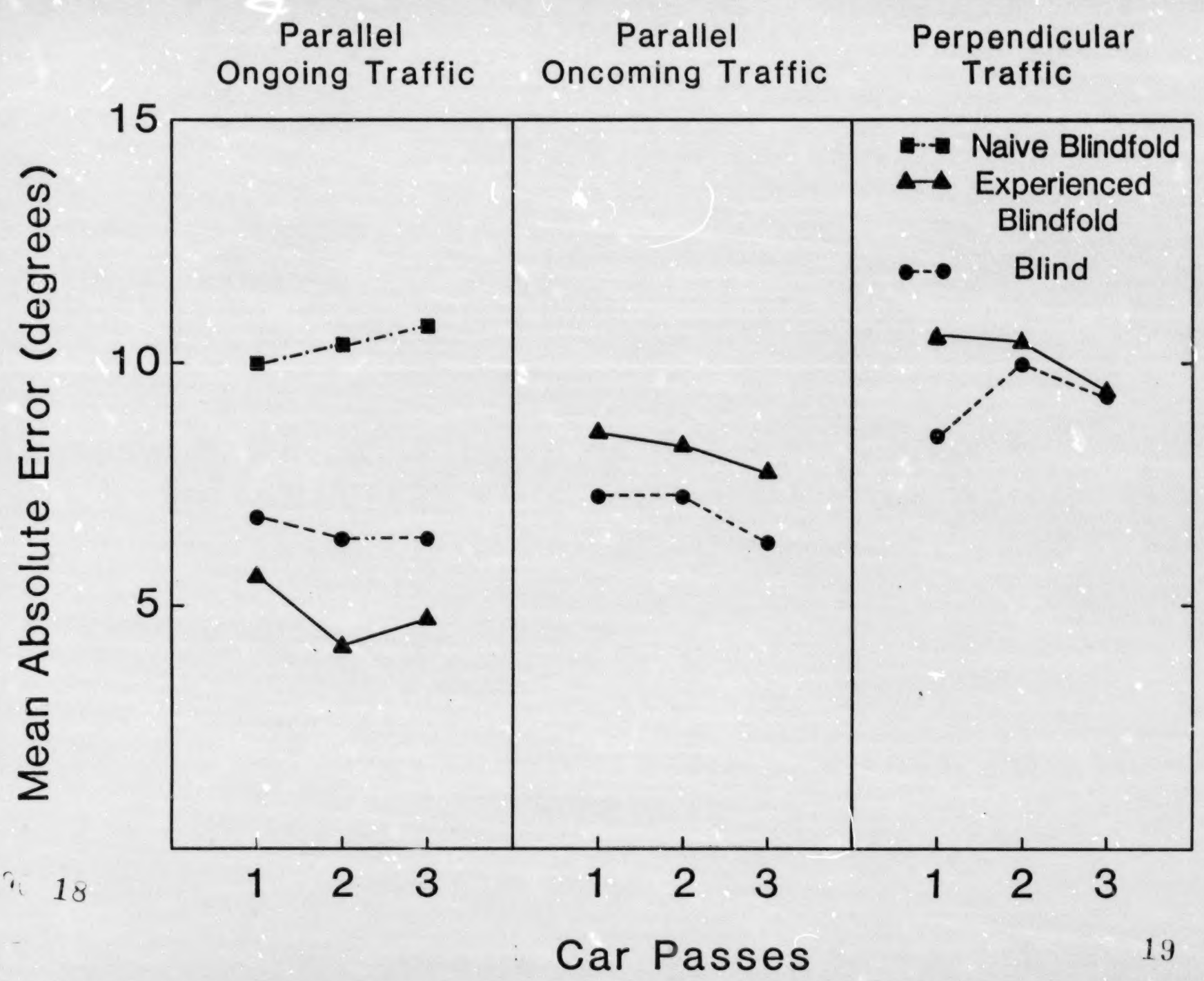


Figure 8. Speed of alignment in car passes for parallel ongoing, parallel oncoming, and perpendicular (cross) traffic.